(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 278 150 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 30.09.92
(51) Int. Cl.5: A63B 69/00, A63B 69/36

(21) Application number: 87305767.3

(22) Date of filing: 29.06.87

(54) Golf game and course simulating apparatus and method.

(30) Priority: 06.02.87 CA 529161

(43) Date of publication of application:
17.08.88 Bulletin 88/33

(45) Publication of the grant of the patent:
30.09.92 Bulletin 92/40

(84) Designated Contracting States:
AT BE CH DE ES FR GB IT LI LU NL SE

(56) References cited:
EP-A- 0 184 410
GB-A- 1 595 791
US-A- 3 563 553
GB-A- 1 514 092
GB-A- 2 150 841
US-A- 3 601 408

(73) Proprietor: JOYTEC LTD
1514 Fletcher Road Saskatoon
Saskatchewan S7M 5M1(CA)

(72) Inventor: Allen, Barry
No. 208, 255 Russell Road
Saskatoon Saskatchewan S7K 7GB(CA)
Inventor: Johnson, Neil
233 Forrester Road
Saskatoon Saskatchewan S7M 4K2(CA)
Inventor: Labbe, Mark
No. 3352, 373 Pendygrasse Road
Saskatoon Saskatchewan S7M 4S2(CA)
Inventor: Lee, Clint
R.R. No. 6
Saskatoon Saskatchewan S7K 3J9(CA)
Inventor: Wacker, Martin
R.R. No. 5
Saskatoon Saskatchewan S7J 3J8(CA)

(74) Representative: Beresford, Keith Denis Lewis et al
BERESFORD & Co. 2-5 Warwick Court High Holborn
London WC1R 5DJ(GB)

Description

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to electronic and data processing apparatus for simulating a game of golf. More particularly, the apparatus senses golf club movement just before it hits a simulated golf ball in order to predict where on an actual image of a preselected hole terrain it would land with tolerable accuracy. More particularly still, the simulated golf ball, when hit, rotates around a substantially vertical axis, whereupon its speed of rotation may be sensed to aid in the prediction of where an actual ball would land. Furthermore, the present invention relates to a method of representing an actual preselected golf course by photographic or the like means for later display to the user of the apparatus. More particularly, the selected golf terrain is partitioned in segments, each segment is photographed, the photographs are digitized and stored on laser video disc for retrieval and display as a game is played.

Prior Art of the Invention

United States Patent 3,601,408 issued August 24, 1971 to Kenneth K. Wright discloses a Golf Swing Training Apparatus, wherein the time and position of a golf club head are sensed photoelectrically at selected stations during a practice swing. Corresponding characteristics of the swing and of the resulting ball flight are computed electronically and displayed to the player via a panel housing display lights, which indicate to the player one of ten flight designations ranging from "Bobble" to "Hard Hook". Two spaced rows of sensors are provided extending transversely of the swing direction of the club. Two signals are derived from the sensor outputs which represent the positions at which the remote edge of the club shadow crosses the respective rows. The sensors of each row may be placed as close together as required to produce the desired accuracy. The attitude of the club head at impact is determined by two sensors spaced along the club face in front of the simulated golf ball to permit evaluation of swing in terms of "square", "open" or "closed" attitude. The club attitude and swing direction are used for deriving an assessment of the flight characteristics of the ball. In addition to flight characteristics, the swing direction and club attitude are also indicated to the player. Finally, the rate of swing of the club between predetermined points is timed by a clock that operates at variable pulse rates. The clock rate is automatically selected in accordance with the computed flight characteristic computed for the same swing. The clock rates are selected such that the resulting digital output is an appropriate measure of the distance in yards.

United States Patent 3,769,894 issued November 6, 1973 to Robert M. Konklin entitled Golf Game teaches the steps of building a model of a golf hole on a reduced scale, the model having a flat playing surface, and photographing the playing surface from differing points on the model. Scenes illustrating portions of the gold hole are displayed to the golfer on a screen on which a spot of light is projected on the displayed scene where computations predicted the ball's trajectory.

United States Patent 4,343,469 issued August 10, 1982 to Yoshisuke Kunita et al discloses a Golf Game Practicing Apparatus capable of simulating the trajectory of a ball during putts. The trajectory of the ball toward the target are displayed on a screen. By means of a mapping transforming section, which alters the image data of the curved surface, the image of the terrain of the green displayed on the screen changes for each approach of the ball toward the target to depict an image closer to the target than that of the preceding putt. The input to the mapping transforming section is the new putt position and the curved surface data.

United States Patent 4,429,880 issued February 7, 1984 to Richard M. Chen et al discloses a Golf Game Simulator Device which permits the golf player to view a specific golf course or portion thereof on a television monitor and is provided with additional information relating to the lie of ball and its position in relation to the hole. The golfer then hits the ball in the normal manner, which ball is fixedly retained on a joystick apparatus, whereby in striking the ball the joystick transmits signals to a computer which generates graphic data relative to a golf course and converts the signal input to graphic display information relative to the new position or lie of the ball in relation to the hole on the golf course. The golf ball is mounted so that when struck, first and second signals for each of four degrees of movement are transmitted to the computer and correlated with the golf course data input. The device in one embodiment utilizes a video disc whereby the course layout is pictorially viewed on a television monitor in addition to graphic information, and the computer determines the pictorial scene to be displayed depending upon the location of the golf ball after being struck by the golfer.

The patent briefly describes an embodiment utilizing a video disc as follows:
"In FIG.4, there is shown a further embodiment of the system, which further embodiment is generally referred to as system 210. System 210 comprises a base 218, computer 213, cassette 280 and television 215, also similar in design and construction to units 118, 113, 80, and 115, respectively, as afore-described. System 210 further contains a video disc player 90 for playing disc 91. Player 90 receives input from computer 213 and selectively display video information, such as a video image of an actual golf course 230 on screen 221. Disc 91 and cassette 280 are of course coordinated so that generated images are of the same subject matter. In addition, the specific tee location or lie of the ball will have a corresponding view or pre-recorded scene on video disc 91. With the computer determined repositioning of the ball after impact, the computer may first generate graphic information relative to the lie of the ball and then instruct the video player to freeze frame the disc 91 to demonstrate the actual vantage point of the golfer as if the golfer were actually positioned on the course at that ball location. Pre-recorded images on the disc 91 may be at various point locations on the golf course spaced on a grid layout of several meters apart.
In utilizing the video disc player, it is important that the computer in accessing the video disc player be able to locate, skip to or jump to a specific point on the video disc so as to display a scene representative of the specific lie of the ball. A disc skip system useful in this regard is that as disclosed in U.S. Pat. No. 3,993,863, granted Nov. 23, 1976 to Leedom, et al."

SUMMARY OF THE INVENTION

The present invention endeavors to provide a compact and realistically simulated golf game apparatus which also has the capability of providing to the user a reasonably accurate analysis of his/her swing.

According to the present invention a golf game simulation apparatus of the kind in which the movement of a golf club head is detected by a plurality of sensors to generate a signal indicative of that movement is characterised in that there are: a first plurality of sensors arranged in a row on one side of and below a simulated or notional golf ball for sensing a golf club head above; and
means for sampling said first plurality of sensors simultaneously at very high frequency and storing the polled information whenever any one or more sensors has undergone a change of state from the previously polled state sampled representation of golf club head movement until said simulated ball is struck by said golf club head.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention will now be described in conjunction with the annexed drawings, in which:

Figure 1 is a perspective view of a golf game simulation apparatus according to the present invention.
Figure 2 is a plan view depecting the rest position of the simulated golf ball of the apparatus in Figure 1.
Figure 3 is a plan view depicting the support mechanism of the simulated golf ball;
Figure 4 is a side elevation of the ball and mechanism shown in Figures 2 and 3;
Figure 5 is an overall block schematic of the electronic and data processing system of the apparatus shown in Figure 1;
Figure 6 is a block schematic of the sensor interface module shown in Figure 5;
Figure 7 is a block schematic of the multiplexer module shown in Figure 5;
Figure 8 is a block schematic of back row photosensors interface circuits interfacing the photosensors shown in Figure 5 to the module of Figure 7;
Figure 9 is a block schematic of front row photosensors interface circuits interfacing the photosensors shown in Figure 5 to the module of Figure 7;
Figure 10 is a plan view of a golf hole fairway illustrating the partitioning of the fairway for purposes of photographing it for digitization and storage on a laser video disc;
Figure 11 is a flow-chart explaining the software of club head movement analysis;
Figure 12 is a flow-chart explaining the software of ball movement parameter computation;
Figure 13 is a flow-chart explaining the software of ball trajectory computation;
Figure 14 is a flow-chart explaining the software for determination of the player's eyeview frame number or address for retrieval and display;
Figure 15 depicts a screen display showing the layout of a selected golf course for player selection of a hole to play; and
Figure 16 depicts a typical screen display of an actual image of the putting green of a selected golf hole.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figures 1-4 of the drawings, the mechanical structure of the golf game apparatus will first be described. A base 20 has an upper surface comprised of two parts 21 and 22; on the extreme end of the surface 22 is erected a housing 23 with a video monitor screen 24 visible at its top and framed by part of the housing 23 which protrudes slightly forward in order to enable light from a lamp 25 underneath the screen 24 to shine downwardly throwing the shadow of objects interrupting it onto the surface 22. From the bottom of the housing 23 at its front protrudes a simulated golf ball 26 mounted on (or integral with) a shaft 27 approximately twelve inches long. The shaft 27 is freely rotatable around a slightly forwardly inclined vertical shaft 28, such that by gravity the ball 26 always returns to its rest position protruding out of bottom opening 29. In order to prevent the shaft 27 from being "stuck" in its quasi-stable position underneath the housing 23 (i.e. 180° away from its forward resting position) three button magnets 30, 31 and 32 are employed. The magnet 30 is disposed adjacent a cylinder 33 integral with and supporting the shaft 27, which is the extension of a tapered portion 34 at the bottom half of the cylinder 33. Embedded in the cylinder 33 at the same level as the magnet 30 is the magnet 31, which is poled to attract the magnet 30 and which is disposed diametrically opposite the shaft 27. This arrangement also provides additional precision in positioning the ball 26 in its rest position. Also embedded in the cylinder 33 is the magnet 32 which is poled to repel the magnet 30 when the shaft 27 is rotated 180° from its forward resting position. The magnet 32 is embedded in the cylinder above the shaft 27 at the same level as the magnet 30.

The upper part of the cylinder 33, in addition to housing the magnets 31 and 32 embedded therein, also serves as a braking surface against which a brake pad 35 is pressed by means of lever 36 which is actuated by solenoid 37 in order to stop rotation of the cylinder (and the ball 26) around the shaft 28 once the ball 26 has been hit by a golf club swinging player (not shown). A return spring ensures that the lever 36 returns to its quiescent position and so the brake pad 35.

The ball 26, the shaft 27 and the cylinder 33 are preferably machined from a single block of a durable synthetic material such as polythylene or the like.

Housed just under the top surface 22 symmetrically on either side of the ball 26 and shaft 27 are two parallel rows (parallel to the shaft 27) of phototransistors 39 and 40, which are 4½ inches apart and which have their lenses pointing upward. The two rows of phototransistors 39 and 40 respond to light or shadow through two transparent protective strips 41 and 42 in the top surface 22. The two rows 39 and 40 are mounted on two printed circuit boards 43 and 44, on each of which are mounted an additional pair of phototransistors 45/46 and 47/48. The phototransistors 45 and 47 are disposed 1 5/8 inches from the rows 39 and 40, respectively, and are exposed to light or shadow via a transparent protective strip 49 in the top surface 22. The function of the phototransistors will be described in conjunction with the electronic data processing circuit description below.

In addition to the two rows of phototransistors 39 and 40, which shall henceforth be termed front rows 39 and 40, there are two back rows (not shown in Figure 2) which are parallel to the rows 39 and 40 and which are mounted on PC boards 43 and 44. One back row is mounted 5½ inches to the right of the front row 39 and the other back row 5½ inches to the left of the row 40.

Turning now to Figure 5, the overall organization of the electronic and data processing system will be described. The system comprises a CPU 50 (which is commercially available as a 8088 (INTEL) motherboard such as that in IBM's XT PC) and its address, data and control bus 51. Connected to the bus 51 are the following subsystems or modules:

- a video disc controller 52 and its associated graphics generator and overlay unit 53 (both are integrated in a commercially available unit "V:Link 1000" from VISAGE); the controller controls a video disc player (SONY) 54, the standard NTSC video output of which is delivered to a video monitor display 55 having a touch responsive screen 24 after having generated graphics (if any) overlayed thereon by the graphic generator 53;
- a CD ROM controller (SONY) 56, which controls CD ROM player (SONY) 57. A floppy disc drive or other random access memory device may replace these CD units;
- a 2 × 8K byte EMPROM 58, which is necessary to contain the program for operating the CD ROM controller 56, and which stores the BIOS program of the CPU 50.
- a microprocessor (8051) in the sensor interface module 59, which responds to the data from the touch screen 24 of the display 55; and
- a multiplexer module 62 which multiplexes and preprocesses signals from: right and left photosensor PC boards 43 and 44, respectively; weight sensor 62; and club height sensor 64 if one is used.

The video disc player 54 accepts laser discs having digitized photographs of selected golf courses as well as menu displays for interacting with the user of the game. Each laser disc has associated with it a CD

ROM containing data (apart from pictures) specific to the golf course on the laser disc, such as distances, contour and topographical data of the hole fairways, in addition to the addresses of each photograph stored on the laser disc.

The CD ROM also stores the main game program shown at the flow chart level in Figures 11 to 14.

Figures 6 and 7 show the block diagrams of the sensor interfacer module 59 and the multiplexer module 62, respectively. The sensor interface module 59 comprises a microprocessor 65 (8051), which includes a 4K byte ROM, two programmable timers, a serial input/output buffer, and a parallel input/output buffer which interfaces with the bus 51 of the CPU 50. A decoder and buffer 66 decodes and buffers the bus 51, and enables a solenoid decoder 67 which activates either the brake solenoid 37 or a second solenoid(not shown) to raise the shaft 28, thereby raising the simulated ball 26 to a slightly higher position (¾ inch) above the top surface 22, thus simulating a tee-off position to the player. A 2K byte non-volatile RAM 68 retains vital statistics such as cummulative number of hits, total money intake, and so forth. A 16-bit programmable counter 69 (8254) is a hardware controlled timer which times the golf club movement and starts timing when the respective back row is crossed by the club shadow and stops when the ball 26 is hit.

Since the game apparatus should be usable by right and left handed players, the two PC boards 43 and 44 bearing photosensors on either side of the ball 26 were necessary. In fact, the PC board 44 is identical in construction to the PC board 43 (for reasons of manufacturing economy), but when installed the PC board 44 is rotated 180° and the resultant interchange of photosensor positions is taken care of by the software and hardware. As a result of the right/left hand choice, it is necessary to multiplex the photosensor and other signals in the multiplexer module 62 shown in more detail in Figure 7. Thus the inputs to the multiplexer are duplicate inputs from the right and the left PC boards 43 and 44. For example, MUX 70 accepts data bits DO(R) to D7(R) and D0(L) to D7(L) from the right front row 39 and the left front 40, respectively. In fact, as will be seen below, the front rows 39 and 40 yield twenty-four bits each, time multiplexed into three-times-eight parallel bits.

Likewise, MUX 71 accepts four bits AB0(R) to AB3(R) and AB0(L) to AB3(L), which are the result of preprocessing of twenty-one photosensors in the right and left back rows (one of which is shown as SB0 to SB20 in Figure 8), respectively. The outputs of MUXs 70 and 71 are to the DATA lines on the bus 51.

MUX 72 multiplexes other right/left functions, such as ball hit (BH) signals. These functions will be explained in conjunction with the description of system operation. The output of the MUX 72 also controls ultrasonic sensor and timer in the club height sensor 64, as well as ball timer 73.

Also shown in Figure 7 is a strain bridge 74 and A/D converter 75 in the weight sensor 63. The strain bridge 74 is under the right hand side of the top surface 21 of the platform 20 (in Figure 1) and serves to fix a reference point related to the user's weight prior to commencement of play. The relative departure from that reference weight during club swing action by the player is used to display swing analysis information (i.e. percentage weight distribution between left and right feet as a swing is progressing) to the player following principles well known to those skilled in golf teaching and analysis. The A/D converter 75 converts the analog output of the strain bridge 74 to computer readable data.

Turning now to Figures 8 and 9, which show circuits on either of the identical PC boards 43 and 44, the first shows back row 76 comprising phototransistors, SB0 to SB20, while the latter shows the front row 39 (or 40, of course) comprising phototransistors SF0 to SF22. All phototransistors are manufactured by General Electric and sold under part number GE L14Cl. Due to the circuit used to obtain the necessary sensitivity, it has a high output impedance and it is necessary to buffer the phototransistors prior to any signal processing.

In the circuit for processing the signals from the phototransistors SB0 to SB20 four CMOS buffers 77 to 80 and four associated latches 81 to 84 are utilized. The four buffers 77 to 80 also perform a simple multiplexing function, depending on whether the back row 76 is on the right hand side of the ball 26 or on the left hand side thereof, i.e. whether the board is used as PC board 43 or as PC board 44. When detecting the swing of a club, only the sixteen phototransistors which are closest to the player are utilized. Thus, for example, the buffer 77 selects either the phototransistors SB0 to SB3 (in the case of a right handed player) or SB17 to SB20 (in the case of a left handed player). The remaining buffers 78 to 80 are connected as shown in the drawings. The output of the selected sixteen phototransistors is latched by the latches 81 to 84, the outputs of which is processed by a priority encoder 85 comprising two TTL priority encoder chips 86 and 87 (74LS148) and three NOR gates 88 to 90.

The output of the priority encoder 85 is a four bit word encoding the phototransistor furthest from the player which has been crossed by the golf club shadow.

The four bits AB0 to AB3 are applied to the back row MUX 71 for left/right selection.

In the circuit for processing signals from SF0 to SF22 again CMOS buffers 91 to 93 are utilized, the twenty-three signal bits plus one integrity "toggle bit" (generated by toggle bit generator 94) are latched by

means of tri-state latches 95 to 97, which are enabled in succession to yield a twenty-four bit word time multiplexed in three eight bit words D0 to D7, which eight parallel bits are applied to MUX 70 (Figure 7). The tri-state latches 95 to 97 are controlled by controller 98, which enables them in succession. The controller 98 processes BALL HIT, IOR (In/Out Read) and DACK (DMA Acknowledge) signals from the CPU 50 and outputs a DRQ (DMA Request) signal. The controller 98 comprises a finite-state machine based on TTL shift registers 99 and 100, which generate properly timed control signals to successively enable the latches 95, 96 and 97 to output their latched bytes, and which generate the DMA request signal DRQ.

Figure 10 is an overview of a golf hole fairway 101 having a tee 102, a hole 103 in a putting green 104. In order to be able to simulate a game of golf on the apparatus of the present invention, the fairway 101 is partitioned into horizontal lines every fifty yards. Thus between the tee 102 and the hole 103 there are imaginary horizontal lines 105 to 108, each of which may be partitioned into rectangles reaching twenty-five yards on either side thereof centered around centers such as 109 and 110. The centers on each horizontal line are fifteen yards apart, so that every rectangle is fifty-by fifteen yards. Of course, there may be as many horizontal lines and as many centers per line as desired to obtain a requisite level of accuracy. The point is that during use of the apparatus if the hypothetical golf ball is computed to fall in one of the rectangles centered around a center, such as 109 or 110, the apparatus would display a photograph taken from the respective center in the direction of the hole 103. Therefore, in photographing the fairway 101, a photograph is taken from a center such as 109 looking at the hole 103. In addition, around the hole 103 the putting green 104 and surroundings are partitioned into three concentric areas:

an outer circle 111 of fifty yards diameter, a circle 112 of 35 yards diameter, and a smaller circle 113 of 15 yards diameter. A photograph looking at the hole 103 is taken from points on the circles 111 to 113 at 45° intervals. In addition, a single photograph is taken from a position 114 five yards away from the hole 103. Accordingly, there are twenty-five photographs around the hole 103, while in the example of Figure 10 the fairway 101 yields twenty-eight photographs, for a total of fifty four photographs including the one from above, typically, per golf hole. Rather than take actual photographs, the fairway 101 is video taped and the single video frames are each assigned an address. The full golf course, if so desired, is mastered on tape and then remastered on video disc. Video taping and mastering is available from CTI Communications of Saskatoon, Saskatchewan, Canada. Transfer on video disc is available from the 3M Company, U.S.A. The stored frames are later retrieved for display by means of their address on the video disc. A particular frame, say it was taken from the center 109, is retrieved for display as computations reveal that the hit by a golf club of the simulated ball 26 would have landed a hypothetical ball within the confines of rectangle 115 centered around the center 109. Had the hypothetical ball been computed to hit a tree 116, a further randomising computation would yield a random position of the lay of the hypothetical ball 117 in the vicinity of the tree 116. Likewise, should the lay of the hypothetical ball be computed to fall in water trap 118, the apparatus would display the appropriate frame while the graphics and overlay generator 53 would display a splash 119 in the water trap 118.

System operation will now be described with reference to the preceding drawing figures and Figures 11 to 14 showing flow charts of system software.

As use of the installed apparatus as shown in Figure 1 commences, the player is prompted by a screen message to stand on the right hand side of the top surface 21 in order to obtain a reference reading of the players weight by means of the strain bridge 74 located underneath. Changes in weight relative to the reference reading, which are registered by the strain bridge 74 during swing action, are recorded and provide swing analysis information to the player later on if requested.

Once the weight calibration is completed, the player is prompted by a screen message to indicate a choice between right handed and left handed swing by touching the appropriate area on the display screen 24. This will determine which of the two printed circuit boards 43 and 44 will be the primary operative board and the software is configured accordingly.

From the video disc in the player 54 the overall layout of the golf course, as shown for example in Figure 15, is retrieved and displayed to the player on the screen 24 for selection of the hole the player wants to play. Once selection is completed by the player having touched the appropriate hole number on the screen 24, a top view of the hole fairway, such as that shown in Figure 10 without the explanatory markings, is displayed to the player with the relevant information such as distance between the tee 102 and the hole 103.

The interaction between the player and the machine continues via screen prompting and messages to which the player reacts by making a choice. For example, since the player is using actual golf clubs to hit the ball 26, an array of standard golf clubs is displayed to the player where a choice is indicated by touching the screen to select a club identical to the one that the player will actually use.

Let us now assume that a player has selected a hole and a club, and that the first eyeview picture from

the tee 102 is displayed on the screen 24. Once the player commences the swing and the club shadow passes the back row 76 phototransistors the priority encoded bits AB0 to AB3 from the priority encoder 85 indicate to the CPU 50 the phototransistor in the back row 76 which is furthest away from the player. This is the only set of data that is provided from the back row 76, and it is latched but held only if the ball 26 hit is indicated by the shaft 27 crossing the phototransistor 47 in the PC board 44. The BALL HIT signal starts the ball timer 73, while the shadow crossing of the shaft 27 of SF4 for left-handed swings and SF18 for right-handed swings stops the ball timer 73. Otherwise, if no ball hit is indicated, a false swing is indicated after approximately sixty-five mS, for example when the player is merely addressing the ball.

It should be noted at this point that when the player hits the ball the default aim point is the hole 103. Should the player during play wish to change the default aiming direction of the system, for example because of a particular lay of the ball, the player may do so by requesting the overall view of the fairway 101 to be displayed and by touching the screen at the chosen aiming point. The change in aiming direction is then accomplished by the system with simple coordinate transformation through an appropriate software routine.

Among other things initiated by the shadow of the club crossing the back row 76, is that continuous sampling of the front row 39 phototransistors is commenced every nine clock cycles, i.e. every 7.54 uS, until the ball 26 has been hit by the club. Every sampling of the front row 39 produces twenty-four bits that are transferred in three-times-eight parallel bits via direct memory access of the CPU 50. Thus when the direct memory access controller chip (8237A-5) grants a DMA request, the front row interface circuit shown in Figure 9 transfers three bytes of information directly into the CPU's 50 random access memory. Each of the phototransistors SF0 to SF22 in the front row 39 corresponds to one bit in the three-byte word transferred, where a ONE indicates that the corresponding phototransistor is under the golf club's shadow. Because the PC boards 43 and 44 are identical, as mentioned earlier, data for the right hand swing is transferred with the phototransistor SF22 nearest the player; while data for a left hand swing is transferred with the phototransistor SF0 nearest the player. The bit number 23 in the three-byte word does not correspond to any phototransistor, but toggles between ZERO and ONE once every sampling. The toggle bit serves as an error checking bit in the programming to ensure that the information is being transferred correctly. DMA transfers continue every nine clock cycles until the ball is hit with the bytes stored in consecutive memory locations in a 60K DMA memory buffer, the pointer of which, once the buffer is full, is automatically reset to the top of the buffer. This "wrap-around" continues until the ball 26 is hit as indicated by the photosensor 47. With a DMA buffer size of 60K bytes, it is possible to measure club swings as slow as approximately .5 miles per hour. Once the sampling of the front row 39 is completed, the DMA buffer memory will contain several thousand successive frames or "snapshots" of the profile of the club's shadow as it passed over the front row 39. It is now possible to compute club parameters, such as club velocity, horizontal approach angle, impact positions, face angle, and vertical approach angle. The computation of this parameters will now be discussed with particular reference to the flow chart shown in Figure 11.

The club shadow is analyzed to give a snapshot of the leading edge of the club as it crosses the front row 39 in the form of an array giving the time of crossing for each sensor relative to the time of crossing of the first sensor crossed. From the leading edge array the position of the club as it crosses the front row 39 can be calculated as well as the club face angle.

The horizontal approach angle Haa is computed as follows:

$$\mathrm{Haa} = \mathrm{atan}\left[\mathrm{Ssens}\,\frac{\mathrm{Bcp} - \mathrm{Fcp}}{\mathrm{Sbf}}\right],$$

where

Tbb =	time for club to travel from back row to ball
Sbb =	separation between backrow and ball
VcMag =	club speed = Sbb/Tbb
Sbf =	separation between back row and front row
Fcp =	club position at front row
Bcp =	club position at back row
Ssens =	photosensor separation (= 0.5 inch)

The club face angle Cfa is computed as follows:

$$Cfa := atan\left[VcMag.Count.\frac{Tcf - Tcn}{2\ Ssens}\right],$$

where

Tcc =	time count at sensor closest to center of club
Tcf =	time count one sensor from center sensor farthest from player
Tcn =	time count one sensor from center sensor nearest to player
Count =	number of timer counts between front row sensor readings

The vertical approach angle Vaa is computed as follows:

$$Vaa = atan\left[Shfta(\ Shda - tan(Haa)\ ) + Fcp\frac{ShdA}{HL}\right],$$

where

Shfta =	tangent of the angle that the club shaft makes with the vertical
Shda =	tangent of the angle that the shadow makes with the front row (39)
HL =	height of light (25)

Calculation of ball movement parameters is now explained with reference to Figures 12 and 13. The routine that calculates the ball movement parameters takes the club head analysis data and uses this data to calculate the ball velocity Vb and the ball spin vector Spin as follows:

Vb =	VcMag (NormFact.VcNorm + TanFact.VcTan)
Spin =	SpinMag.SpinDirn, where
CfNorm =	unit vector normal to face of club
Cla =	club loft angle
α =	Cfa + Vaa
$CfNorm_x$ =	tan(Cfa) cos (α)
$CfNorm_y$ =	(cos (α) + tan (Cfa) .sin (α) .Shfta)
$CfNorm_z$ =	(sin(α) - tan (Cfa) .cos (α) .Shfta)
	(CfNorm is now converted to a unit vector)
VcDirn =	unit vector in direction of club velocity
VcNorm =	component of club velocity normal to club face
VcTan =	component of club velocity tangent to club face
SpinDirn =	unit vector in the direction of the spin vector
SpinMag =	magnitude of spin vector
NormFact =	factor translating normal component of club velocity based on impact dynamics
TanFact =	factor translating tangential component of club velocity based on impact dynamics
SpinFact =	factor translating club speed to spin magnitude
$VcDirn_x$ =	cos(Vaa). sin(Haa)
$VcDirn_y$ =	cos(Vaa). cos(Haa)
$VcDirn_z$ =	sin(Vaa)
VcNorm =	innerprod (CfNorm, VcNirn). Cfnorm
VcTan =	VcDirn - VcNorm
SpinDirn =	vectorprod (VcDirn,CfNorm)
SpinMag =	SpinFact .Vcmag

The eyeview calculation which yields the address of the picture to be retrieved from video disc player 54 is explained with particular reference to Figure 14. The calculation of the eyeview for a given location on the golf course is determined from three arrays. The first of these defines the areas on the course for which a particular eyeview will be displayed. It is a two dimensional array which defines a sequence of up to 12 contiguous intervals (i.e. rectangles such as 115 in Figure 10) for each screen row 105 to 108. It is of the form Xmin[Row,i] where 0<Row<191 and 1<i<12. The entries in this array are the left hand endpoints of the intervals. The second array defines the eyeview number for each of the areas defined by the Xmin array. It

is of the Form Eview = Mat[Row,i] and each element gives the eyeview number corresponding to the area containing the interval defined by Xmin. The third array is the eyeview table. It is of the Form Frame = Mat-[Eview] where 1<Eview<MaxEview. The entries in this table are the actual frame numbers on the video disc corresponding to the eyeview number.

Claims

1. A golf game simulation apparatus of the kind in which the movement of a golf club head is detected by a plurality of sensors to generate a signal indicative of that movement characterised in that there are: a first plurality of sensors (39,40) arranged in a row on one side of and below a simulated or notional golf ball (26) for sensing a golf club head above; and
means for sampling said first plurality of sensors (39, 40) simultaneously at very high frequency and storing the polled information whenever any one or more sensors has undergone a change of state from the previously polled state sampled representation of golf club head movement until said simulated ball is struck by said golf club head.

2. The golf game simulation apparatus of claim 1, in which the simulated/notional golf ball is an actual golf ball.

3. A golf game simulation apparatus as claimed in claim 1 having a simulated golf ball assembly, comprising a first shaft (27) supported at one end thereof to freely rotate around a predetermined axis (28) and having at its other end a golf ball-like member (26).

4. A golf game simulation apparatus as claimed in claim 3, in which said simulated golf ball assembly comprising a substantially horizontal shaft (27) having a ball-like enlargement (26) at its free end.

5. A golf game simulation apparatus as claimed in claim 4, in which the substantially horizontal shaft (27) supported at its other end by means of, and rotatable around, a substantially vertical shaft (28).

6. A golf game simulation apparatus as claimed in claim 5, in which the substantially vertical shaft (28) is slightly inclined frontwards such that the simulated golf ball (26) comes to rest adjacent the first plurality of sensors (39,40).

7. A golf game simulation apparatus as claimed in any of claims 3 to 6, the shaft (27) being freely rotatable in a substantially horizontal plane.

8. A golf game simulation apparatus as claimed in claim 3, in which a substantially horizontal shaft (27) is supported at one end by means of a second substantially vertical shaft (28) slightly inclined with respect to the vertical such that the golf ball-like attachment(26) comes to rest always at a predetermined position by the action of gravity.

9. A golf game simulation apparatus as claimed in claim 8 in which the substantially vertical shaft (28) is rotatable by means of a gear mechanism which changed the angle of inclination of the shaft (28) from true vertical (in a forward-backwards orientation), so that the height of the golf ball-like attachment (26) above the plane of the sensors is continuously variable over a range of several centimetres.

10. A golf game simulation apparatus as claimed in claim 8 or 9 in which the golf ball-like attachment (26) is integral with the first shaft (27), and the first shaft (27) is rotatable around the second shaft (28) by having the second shaft inserted through a pivoting aperture (33) in the first shaft (27).

11. A golf game simulation apparatus as claimed in claim 10, further comprising braking means (33,35,36) adapted to engage a cooperating surface of a portion of said first shaft (27) to brake its free rotation around the second shaft (28).

12. A golf game simulation apparatus as claimed in any previous claim and which also includes: means for displaying a plurality of still pictures or motion video frames from a plurality of points disposed around a golf hole, golf green, and fairway; means for assignment a retrieval address to each of said pictures or still frames; and

means for storing said pictures or still frames each at its retrieval address in a random access storage medium.

13. Apparatus according to any previous claim, wherein said sensing means comprises an array of photosensors.

Patentansprüche

1. Golfspielsimulator der Art, bei der die Bewegung eines Golfschlägerkopfes durch eine Anzahl von Sensoren erfaßt wird, um ein Signal zu erzeugen, das diese Bewegung anzeigt, dadurch gekennzeichnet, daß vorgesehen sind: Eine erste Anzahl von Sensoren (39, 40), die in einer Reihe an einer Seite von und unter einem simulierten oder angenommenen Golfball (26) angeordnet sind, um einen Golfschlägerkopf darüber zu erfassen; und eine Einrichtung zum gleichzeitigen Abtasten der ersten Anzahl von Sensoren (39, 40) mit sehr hoher Frequenz und zum Speichern der abgerufenen Informationen, wenn immer einer oder mehrere Sensoren eine Zustandsänderung von der vorhergehend abgerufenen abgetasteten Zustandsdarstellung der Golfschlägerkopfbewegung erfahren hat, bis der simulierte Ball vom Golfschlägerkopf getroffen wird.

2. Golfspielsimulator nach Anspruch 1, wobei der simulierte/angenommene Golfball ein wirklicher Golfball ist.

3. Golfspielsimulator nach Anspruch 1 mit einer simulierten Golfballanordnung, mit einer ersten Welle (27), die an einem Ende so gelagert ist, daß sie frei um eine vorgegebene Achse (28) rotieren kann, und die an ihrem anderen Ende ein golfballähnliches Element (26) aufweist.

4. Golfspielsimulator nach Anspruch 3, wobei die simulierte Golfballanordnung eine im wesentlichen horizontalen Welle (27) mit einer ballartigen Vergrößerung (26) an ihrem freien Ende aufweist.

5. Golfspielsimulator nach Anspruch 4, wobei die im wesentlichen horizontale Welle (27) an ihrem anderen Ende mittels einer im wesentlichen vertikalen Welle (28) abgestützt ist, um die sie drehbar ist.

6. Golfspielsimulator nach Anspruch 5, wobei die im wesentlichen vertikale Welle (28) derart leicht nach vorne geneigt ist, daß der simulierte Golfball (26) angrenzend an die erste Anzahl von Sensoren (39, 40) zur Ruhe kommt.

7. Golfspielsimulator nach einem der Ansprüche 3 bis 6, wobei die Welle (27) in einer im wesentlichen horizontalen Ebene frei drehbar ist.

8. Golfspielsimulator nach Anspruch 3, wobei eine im wesentlichen horizontale Welle (27) an einem Ende mittels einer zweiten, im wesentlichen vertikalen Welle (28) abgestützt ist, die bezüglich der Vertikalen leicht derart geneigt ist, daß der golfballähnliche Ansatz (26) durch die Wirkung der Schwerkraft immer in einer vorgegebenen Position zur Ruhe kommt.

9. Golfspielsimulator nach Anspruch 8, wobei die im wesentlichen vertikale Welle (28) mittels eines Getriebe-Mechanismusses drehbar ist, der den Neigungswinkel der Welle (28) aus der echten Vertikalen (in einer Vorwärts-Rückwärts-Richtung) so ändert, daß die Höhe des golfballähnlichen Ansatzes (26) über der Ebene der Sensoren über einen Bereich von mehreren Zentimetern kontinuierlich variabel ist.

10. Golfspielsimulator nach Anspruch 8 oder 9, wobei der golfballähnliche Ansatz (26) einstückig mit der ersten Welle (27) ausgebildet ist, und wobei die erste Welle (27) um die zweite Welle (28) dadurch drehbar ist, daß die zweite Welle mittels einer schwenkbaren Öffnung (33) in der ersten Welle (27) eingesetzt ist.

11. Golfspielsimulator nach Anspruch 10, mit einer Bremseinrichtung (33, 35, 36), die dafür vorgesehen ist, mit einer damit zusammenwirkenden Oberfläche eines Teiles der ersten Welle (27) in Eingriff zu kommen, um deren freie Drehung um die zweite Welle (28) abzubremsen.

12. Golfspielsimulator nach einem der vorstehenden Ansprüche, der des weiteren umfaßt: Eine Einrichtung zur Darstellung einer Anzahl von Standbildern oder sich bewegenden Videobildern von einer Anzahl von Stellen, die sich um ein Golf-Loch, ein Golf-Grün und einen Fairway befinden; eine Einrichtung zum Zuordnen einer Wiederauffindeadresse zu jedem der Bilder oder Standbilder; und eine Einrichtung zum Speichern der Bilder oder Standbilder jeweils unter ihren Wiederauffindeadressen in einem Direktzugriffsspeichermedium.

13. Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Erfassungseinrichtung ein Photosensorarray umfaßt.

Revendications

1. Simulateur de jeu de golf du type dans lequel on détecte le mouvement d'une tête de club de golf au moyen d'un certain nombre de détecteurs de manière à produire un signal représentatif de ce mouvement, simulateur caractérisé en ce qu'il comprend un premier ensemble de détecteurs (39, 40) disposés en une rangée de chaque côté et au-dessous d'une balle de golf simulée ou fictive (26) pour détecter une tête de club de golf placée au-dessus ; et des moyens destinés à échantillonner simultanément le premier ensemble de détecteurs (39, 40) à très grande vitesse et à stocker l'information recueillie à chaque fois que l'un ou plusieurs des détecteurs a subi un changement d'état par rapport à la représentation échantillonnée d'un état précédemment recueilli du mouvement de la tête du club de golf, jusqu'à ce que la balle simulée soit frappée par la tête du club de golf.

2. Simulateur de jeu de golf selon la revendication 1, caractérisé en ce que la balle de golf simulée/fictive est une balle de golf réelle.

3. Simulateur de jeu de golf selon la revendication 1, caractérisé en ce qu'il comporte un dispositif de balle de golf simulée comprenant une première tige (27) montée par l'une de ses extrémités de manière à pouvoir tourner librement sur un axe prédéterminé (28) et comportant à son autre extrémité un élément en forme de balle de golf (26).

4. Simulateur de jeu de golf selon la revendication 3, caractérisé en ce que le dispositif de balle de golf simulée comprend une tige essentiellement horizontale (27) munie d'un agrandissement en forme de balle (26) à son extrémité libre.

5. Simulateur de jeu de golf selon la revendication 4, caractérisé en ce que la tige essentiellement horizontale (27) est supportée à son autre extrémité par une tige essentiellement verticale (28) autour de laquelle elle peut tourner.

6. Simulateur de jeu de golf selon la revendication 5, caractérisé en ce que la tige essentiellement verticale (28) est légèrement inclinée vers l'avant de façon que la balle de golf simulée (26) vienne s'arrêter au voisinage du premier ensemble de détecteurs (39, 40).

7. Simulateur de jeu de golf selon l'une quelconque des revendications 3 à 6, caractérisé en ce qu'on peut faire tourner la tige (27) dans un plan essentiellement horizontal.

8. Simulateur de jeu de golf selon la revendication 3, caractérisé en ce qu'une tige essentiellement horizontale (27) est supportée à une extrémité par une seconde tige essentiellement verticale (28) légèrement inclinée par rapport à la verticale de façon que la fixation en forme de balle de golf (26) vienne toujours s'arrêter dans une position prédéterminée sous l'action de la pesanteur.

9. Simulateur de jeu de golf selon la revendication 8, caractérisé en ce qu on peut faire tourner la tige essentiellement verticale (28) au moyen d'un mécanisme d'engrenage qui modifie l'angle d'inclinaison de la tige (28) par rapport à la verticale véritable (dans une orientation avantarrière), de façon que la hauteur de la fixation en forme de balle de golf (26) au-dessus du plan des détecteurs, soit continuellement variable sur une plage de quelques centimètres.

10. Simulateur de jeu de golf selon l'une quelconque des revendications 8 et 9, caractérisé en ce que la fixation en forme de balle de golf (26) fait corps avec la première tige (27), et en ce qu'on peut faire

tourner la première tige (27) autour de la seconde tige dans une ouverture de pivotement (33) de la première tige (27).

11. Simulateur de jeu de golf selon la revendication 10, caractérisé en ce qu'il comprend en outre de moyens de freinage (33, 35, 36) destinés à venir s'engager contre une surface de coopération d'une partie de la première tige (27) pour freiner sa rotation libre autour de la seconde tige (28).

12. Simulateur de jeu de golf selon l'une quelconque des revendications précédentes, caractérisé en ce qu'il comprend : des moyens pour afficher un certain nombre d'images fixes ou trames vidéo de mouvement à partir d'un certain nombre de points disposés autour d'un trou de golf, d'un green de golf et d'un fairway ; des moyens pour affecter une adresse de restitution à chacune de ces images ou trames fixes ; et des moyens pour stocker chacune de ces images ou trames fixes à son adresse de restitution dans un support de mémoire à accès aléatoire.

13. Simulateur selon l'une quelconque des revendications précédentes, caractérisé en ce que les moyens de détection sont constitués par un réseau de détecteurs photoélectriques.

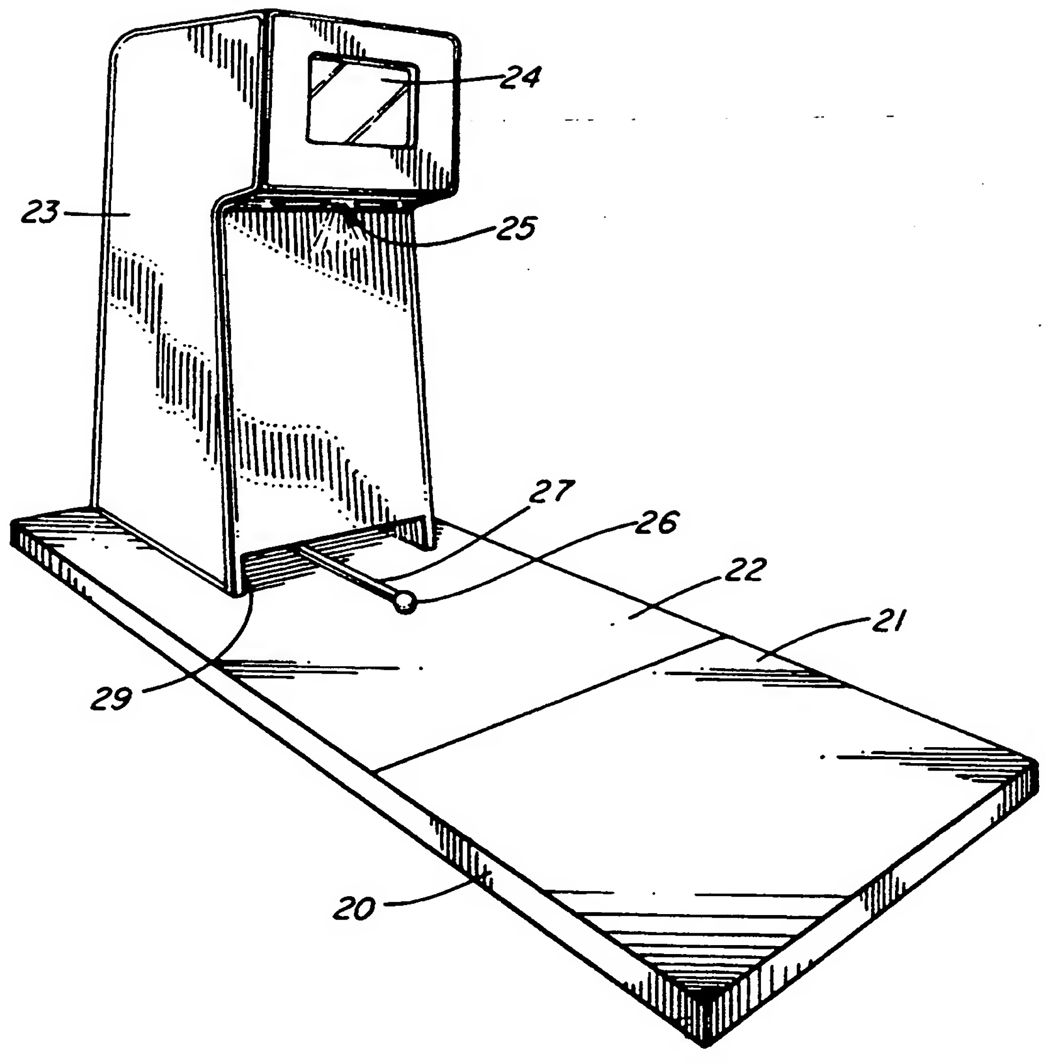

FIG. 1

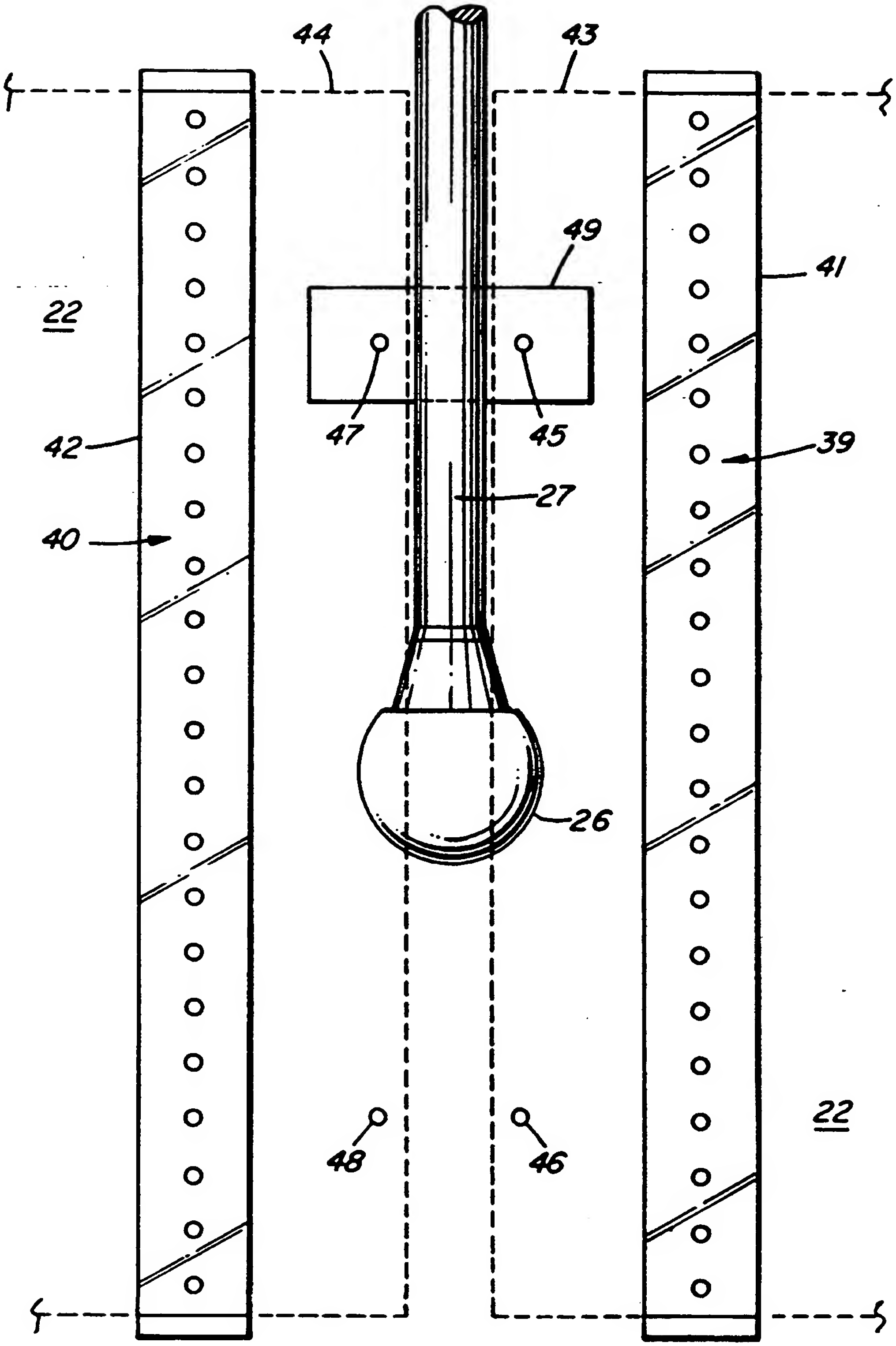

FIG. 2

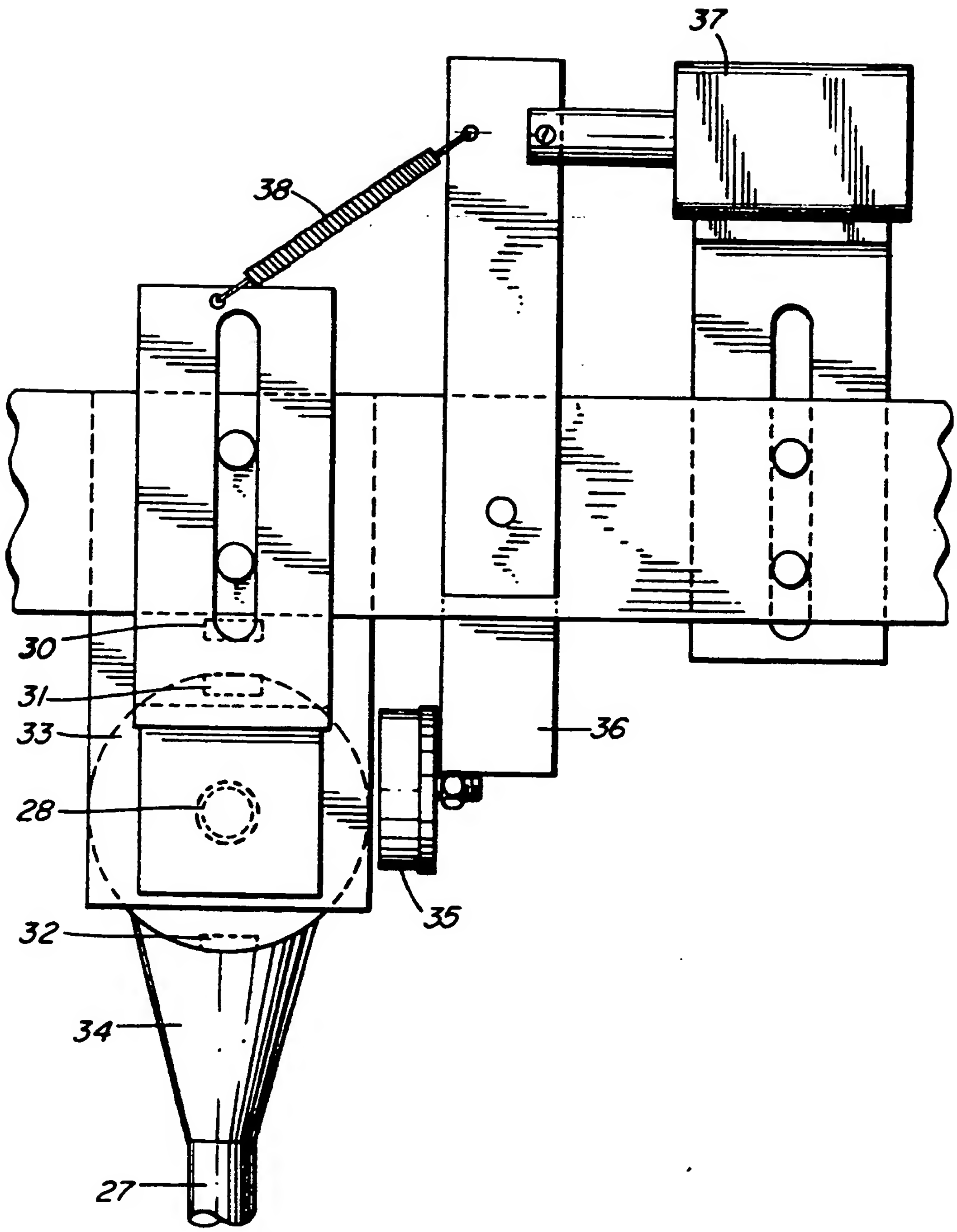

FIG. 3

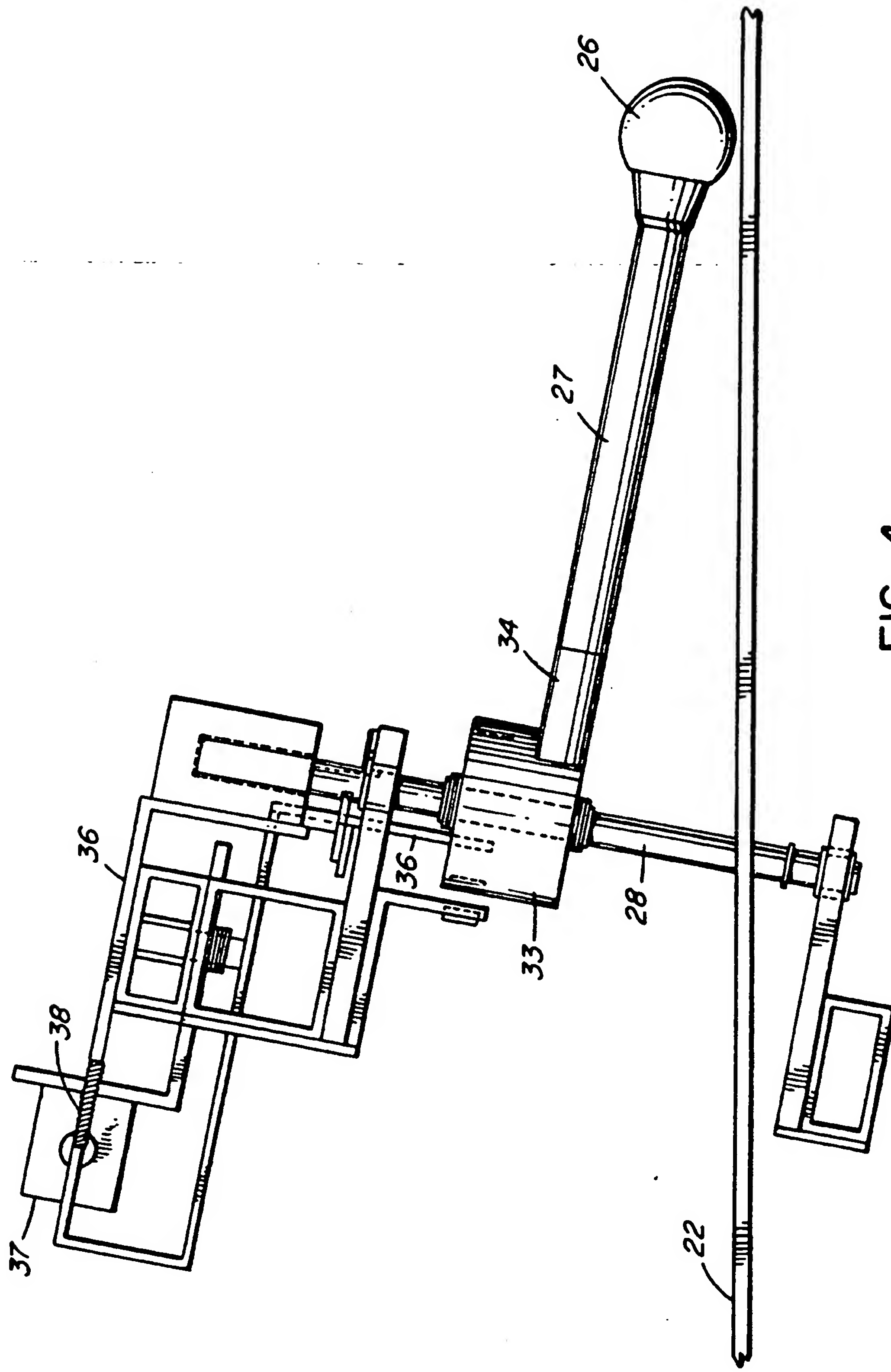

FIG. 4

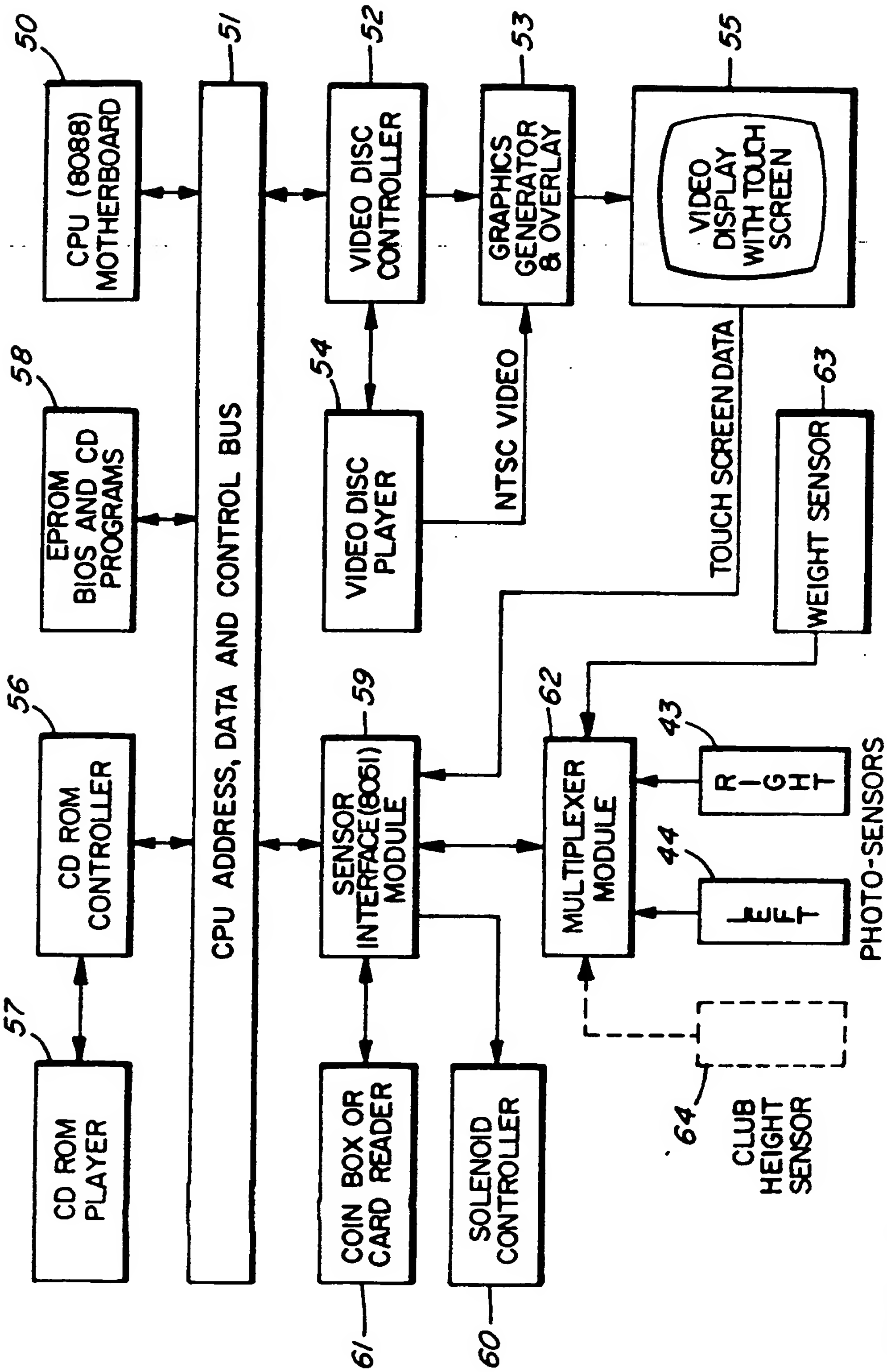
CPU (8088) MOTHERBOARD
50
EPROM BIOS AND CD PROGRAMS
58
CD ROM CONTROLLER
56
CD ROM PLAYER
57
CPU ADDRESS, DATA AND CONTROL BUS
51
VIDEO DISC CONTROLLER
52
VIDEO DISC PLAYER
54
SENSOR INTERFACE(8051) MODULE
59
COIN BOX OR CARD READER
61
GRAPHICS GENERATOR & OVERLAY
53
NTSC VIDEO
SOLENOID CONTROLLER
60
MULTIPLEXER MODULE
62
VIDEO DISPLAY WITH TOUCH SCREEN
55
TOUCH SCREEN DATA
WEIGHT SENSOR
63
RIGHT
43
LEFT
44
PHOTO-SENSORS
CLUB HEIGHT SENSOR
64

FIG. 5

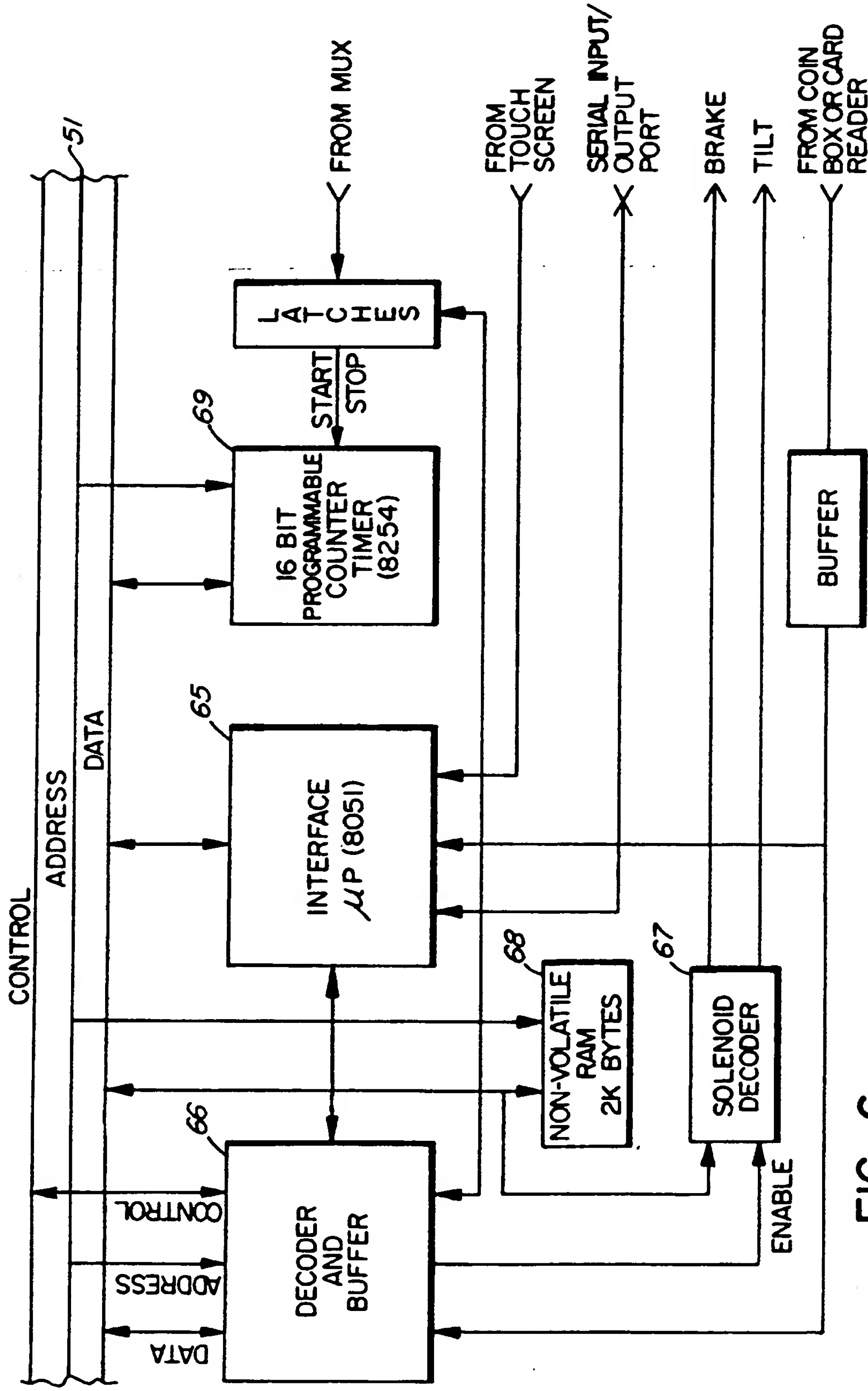
51
CONTROL
ADDRESS
DATA
FROM MUX
FROM TOUCH SCREEN
SERIAL INPUT/ OUTPUT PORT
BRAKE
TILT
FROM COIN BOX OR CARD READER
LATCHES
START
STOP
69
16 BIT PROGRAMMABLE COUNTER TIMER (8254)
BUFFER
65
INTERFACE µP (8051)
68
NON-VOLATILE RAM 2K BYTES
67
SOLENOID DECODER
66
DECODER AND BUFFER
CONTROL
ADDRESS
DATA
ENABLE

FIG. 6

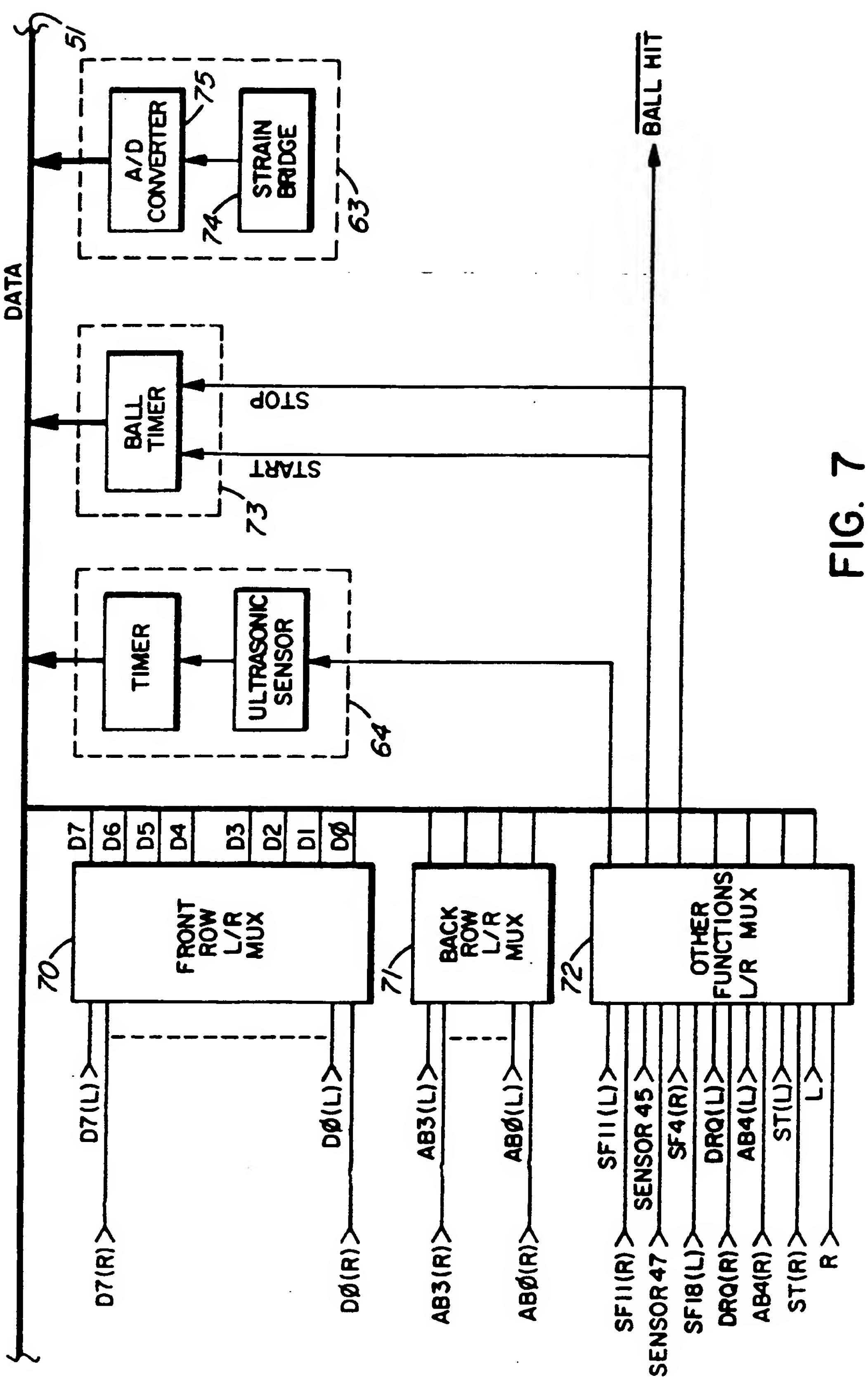
DATA
51
A/D CONVERTER
75
STRAIN BRIDGE
74
63
BALL HIT
BALL TIMER
STOP
START
73
TIMER
ULTRASONIC SENSOR
64
D7
D6
D5
D4
D3
D2
DI
DØ
FRONT ROW L/R MUX
70
BACK ROW L/R MUX
71
OTHER FUNCTIONS L/R MUX
72
D7(L)
DØ(L)
D7(R)
DØ(R)
AB3(L)
ABØ(L)
AB3(R)
ABØ(R)
SF11(L)
SENSOR 45
SF4(R)
DRQ(L)
AB4(L)
ST(L)
L
SF11(R)
SENSOR 47
SF18(L)
DRQ(R)
AB4(R)
ST(R)
R

FIG. 7

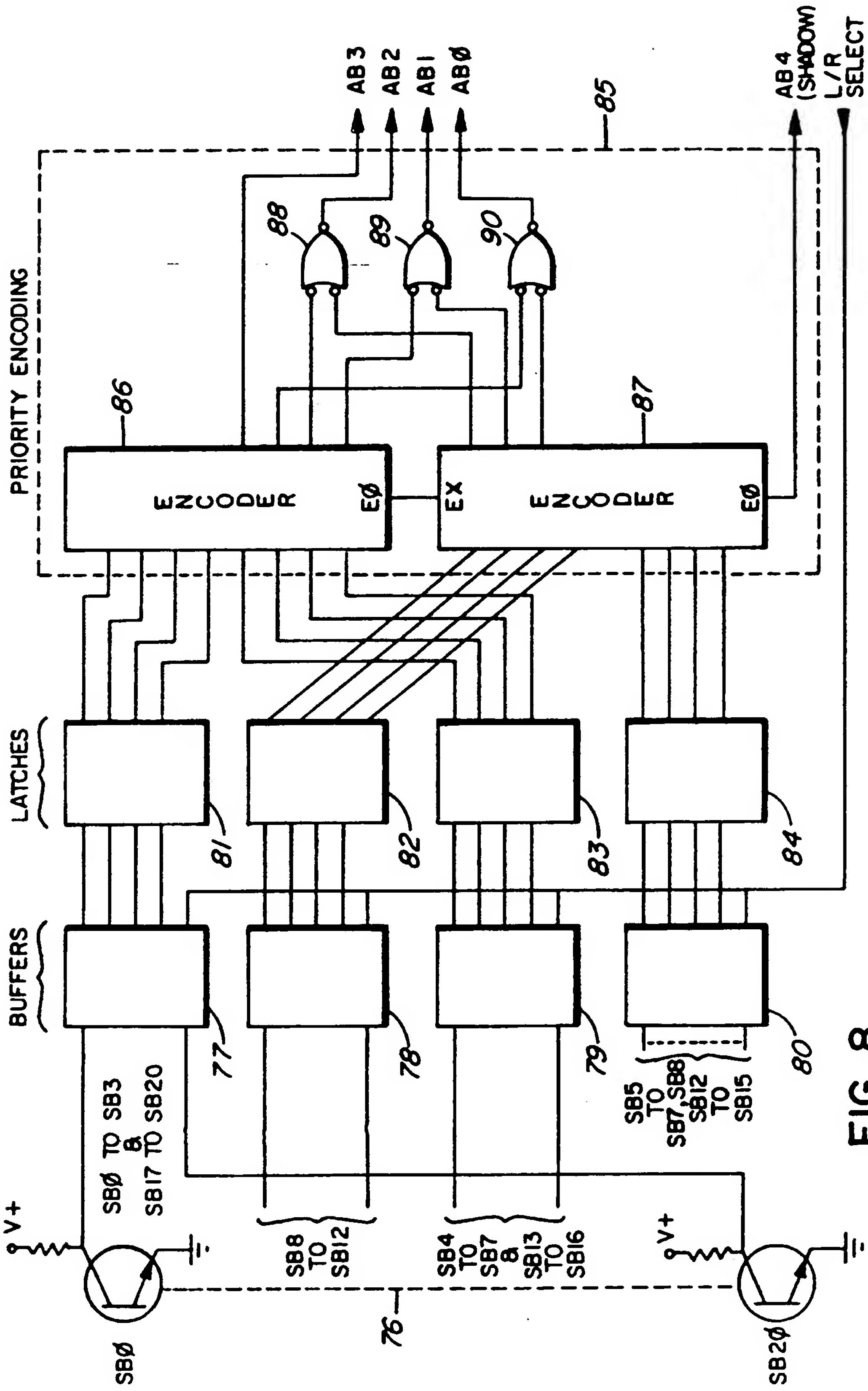
PRIORITY ENCODING
ENCODER
ENCODER
EØ
EX
EØ
AB3
AB2
AB1
ABØ
AB4 (SHADOW)
L/R SELECT
LATCHES
BUFFERS
SBØ TO SB3 & SB17 TO SB20
SB8 TO SB12
SB4 TO SB7 & SB13 TO SB16
SB5 TO SB7, SB8 SB12 TO SB15
V+
V+
SBØ
SB2Ø
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

FIG. 8

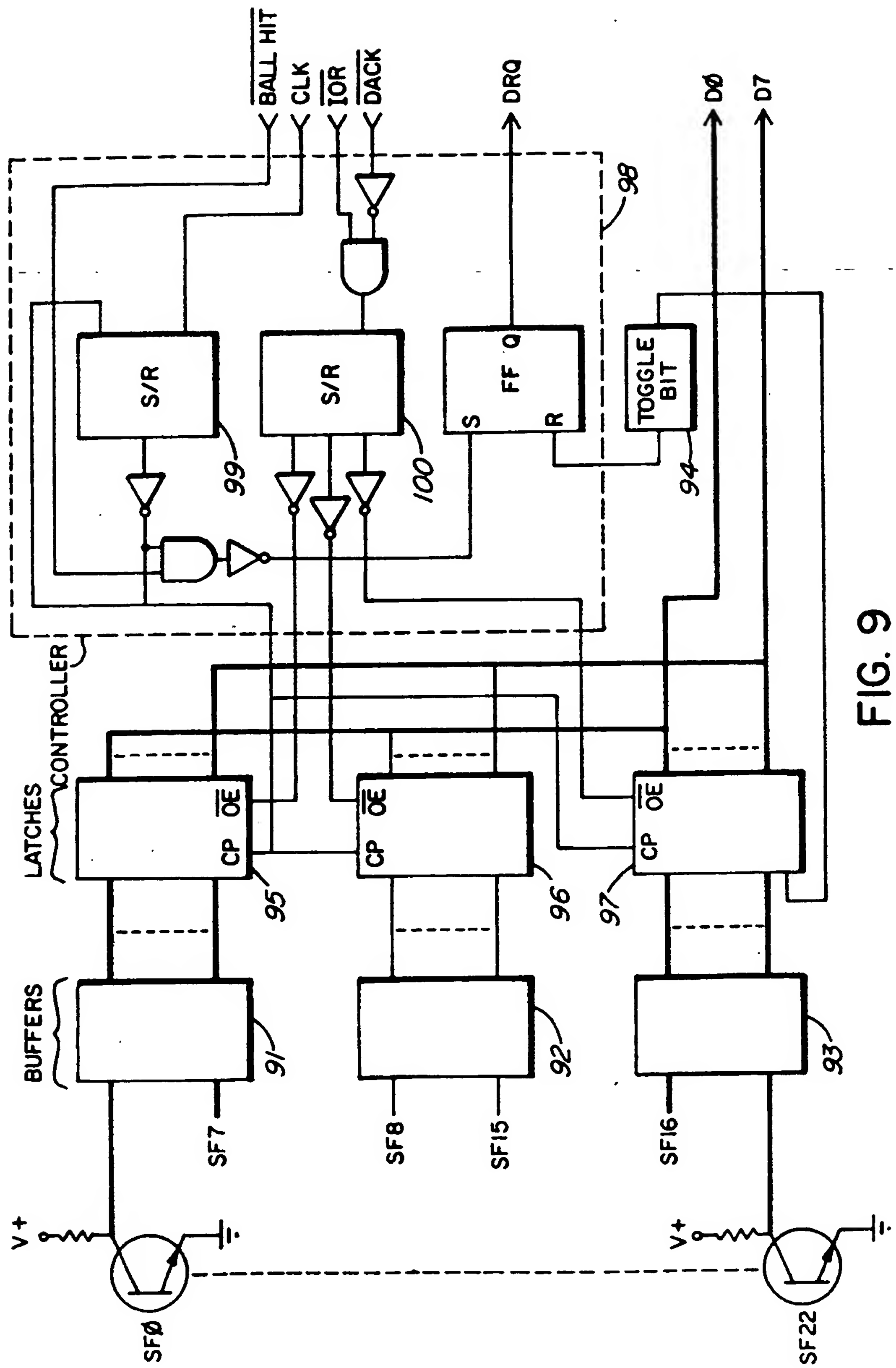
BALL HIT
CLK
IOR
DACK
DRQ
DØ
D7
98
S/R
S/R
99
100
FF
Q
S
R
TOGGLE BIT
94
CONTROLLER
LATCHES
CP
OE
95
96
97
BUFFERS
91
92
93
SF7
SF8
SF15
SF16
V+
V+
SFØ
SF22

FIG. 9

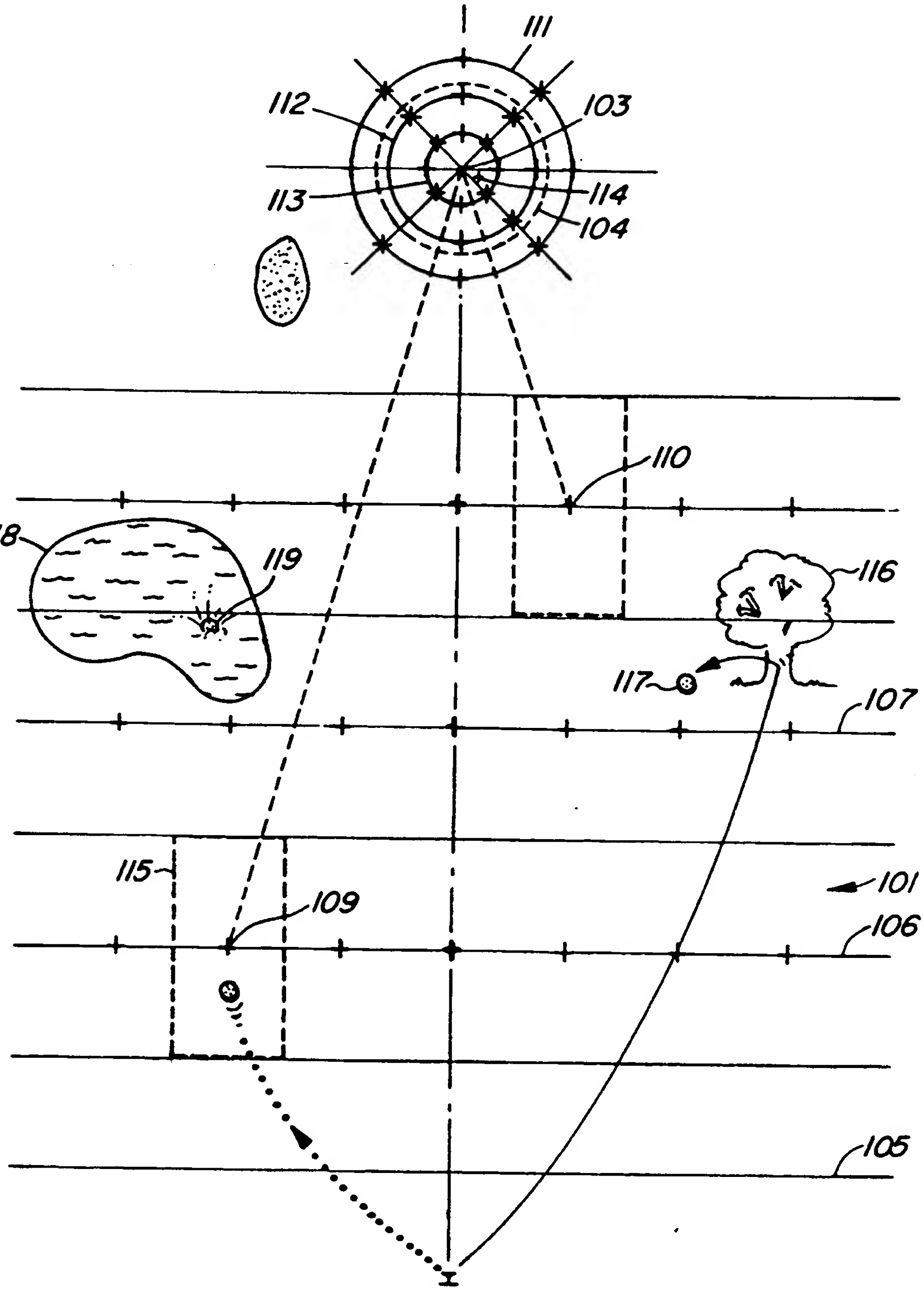
111
112
103
113
114
104
110
118
119
116
117
107
115
101
109
106
105

FIG. 10

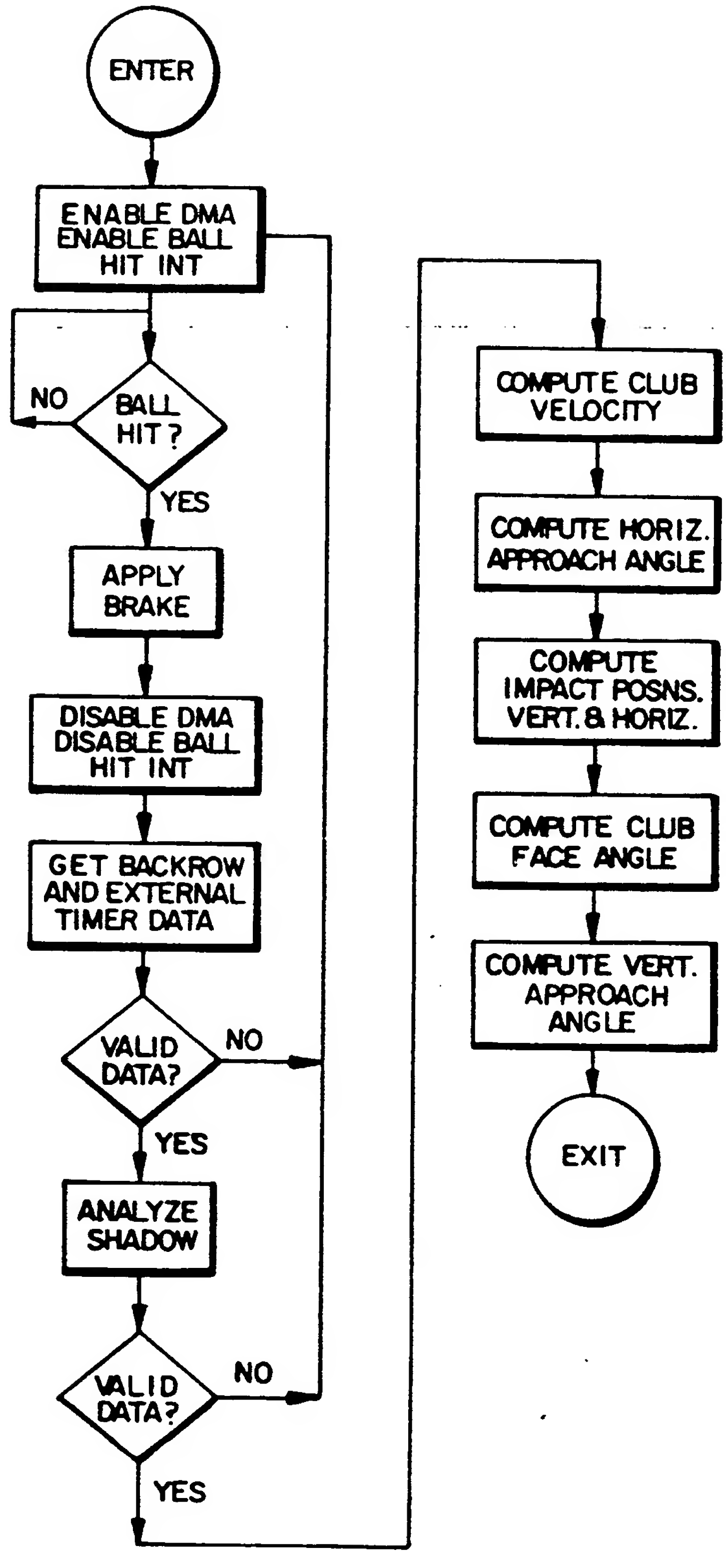
ENTER
ENABLE DMA ENABLE BALL HIT INT
BALL HIT ?
NO
YES
APPLY BRAKE
DISABLE DMA DISABLE BALL HIT INT
GET BACKROW AND EXTERNAL TIMER DATA
VALID DATA?
NO
YES
ANALYZE SHADOW
VALID DATA?
NO
YES
COMPUTE CLUB VELOCITY
COMPUTE HORIZ. APPROACH ANGLE
COMPUTE IMPACT POSNS. VERT. & HORIZ.
COMPUTE CLUB FACE ANGLE
COMPUTE VERT. APPROACH ANGLE
EXIT

FIG. 11

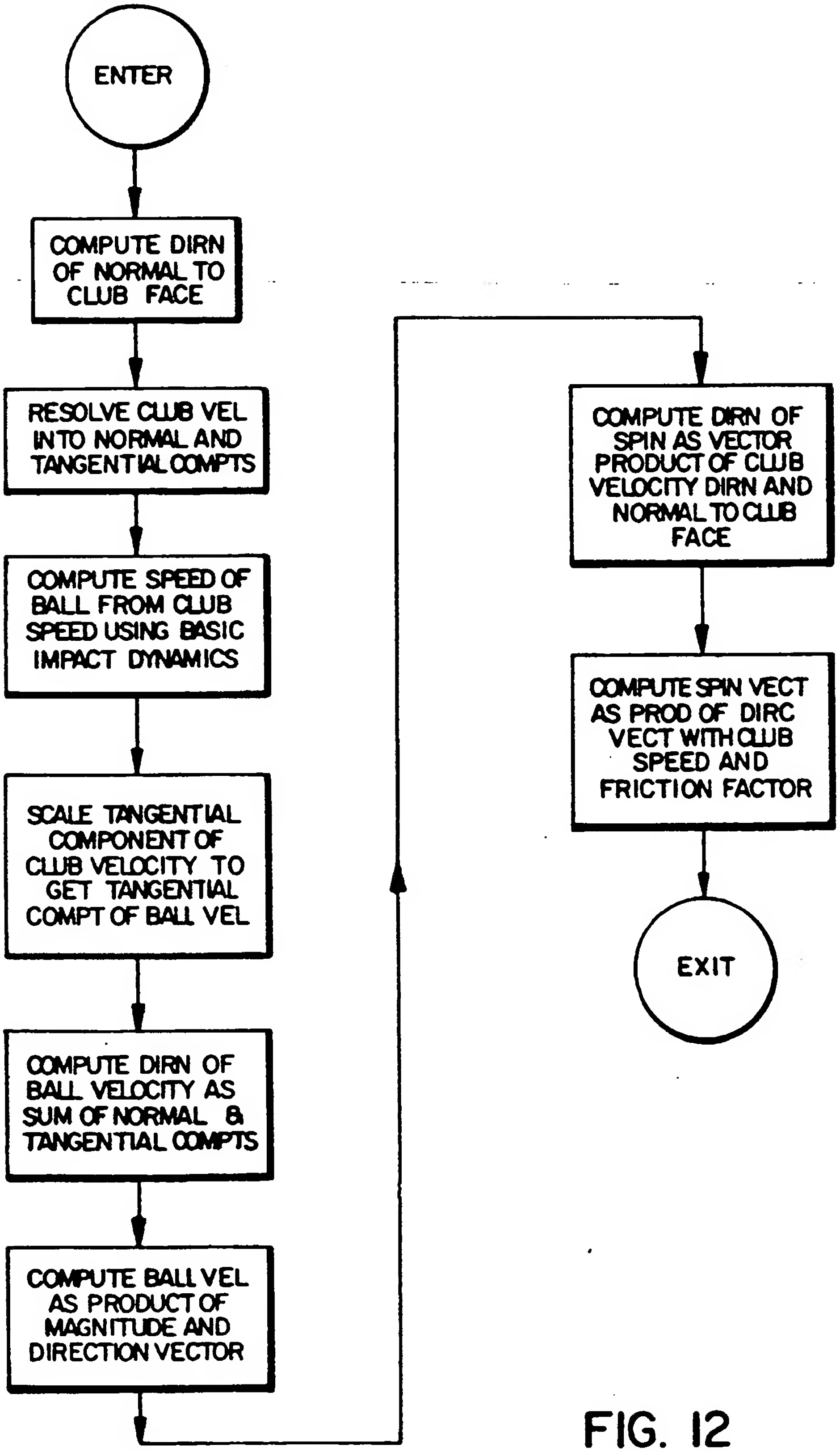
ENTER
COMPUTE DIRN OF NORMAL TO CLUB FACE
RESOLVE CLUB VEL INTO NORMAL AND TANGENTIAL COMPTS
COMPUTE SPEED OF BALL FROM CLUB SPEED USING BASIC IMPACT DYNAMICS
SCALE TANGENTIAL COMPONENT OF CLUB VELOCITY TO GET TANGENTIAL COMPT OF BALL VEL
COMPUTE DIRN OF BALL VELOCITY AS SUM OF NORMAL & TANGENTIAL COMPTS
COMPUTE BALL VEL AS PRODUCT OF MAGNITUDE AND DIRECTION VECTOR
COMPUTE DIRN OF SPIN AS VECTOR PRODUCT OF CLUB VELOCITY DIRN AND NORMAL TO CLUB FACE
COMPUTE SPIN VECT AS PROD OF DIRC VECT WITH CLUB SPEED AND FRICTION FACTOR
EXIT

FIG. 12

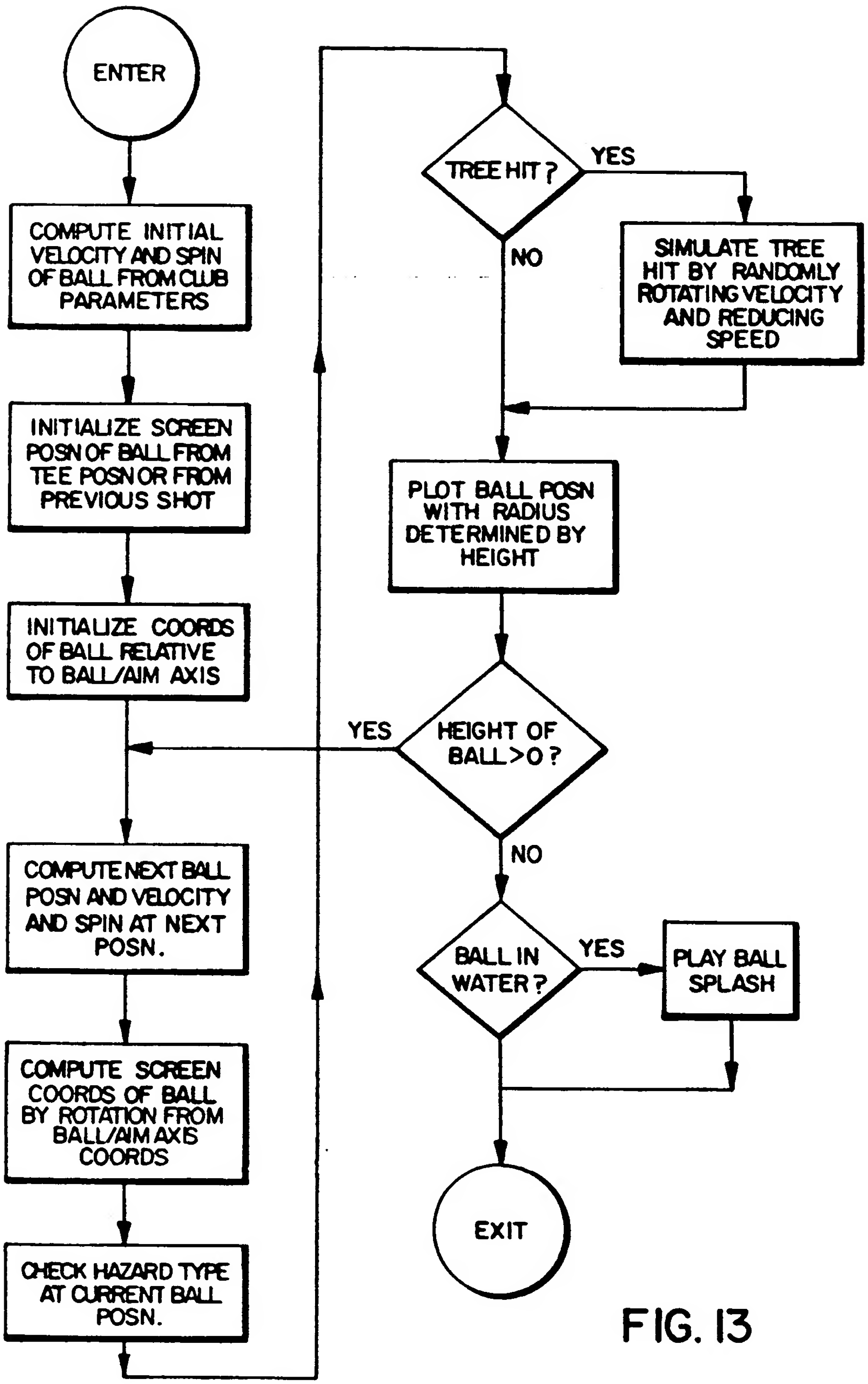
ENTER
COMPUTE INITIAL VELOCITY AND SPIN OF BALL FROM CLUB PARAMETERS
INITIALIZE SCREEN POSN OF BALL FROM TEE POSN OR FROM PREVIOUS SHOT
INITIALIZE COORDS OF BALL RELATIVE TO BALL/AIM AXIS
COMPUTE NEXT BALL POSN AND VELOCITY AND SPIN AT NEXT POSN.
COMPUTE SCREEN COORDS OF BALL BY ROTATION FROM BALL/AIM AXIS COORDS
CHECK HAZARD TYPE AT CURRENT BALL POSN.
TREE HIT ?
YES
NO
SIMULATE TREE HIT BY RANDOMLY ROTATING VELOCITY AND REDUCING SPEED
PLOT BALL POSN WITH RADIUS DETERMINED BY HEIGHT
HEIGHT OF BALL>O ?
YES
NO
BALL IN WATER ?
YES
PLAY BALL SPLASH
EXIT

FIG. 13

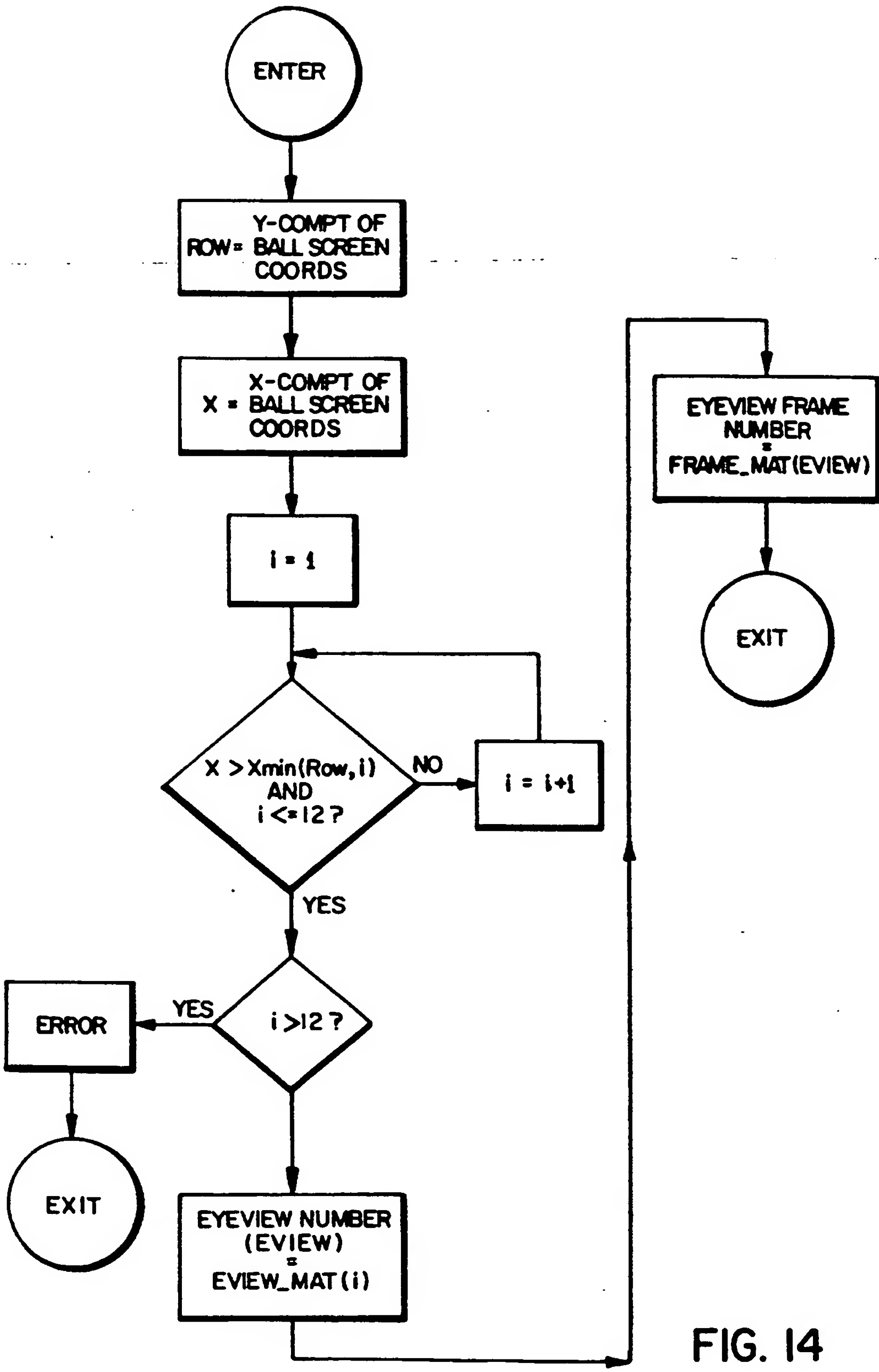
ENTER
ROW = Y-COMPT OF BALL SCREEN COORDS
X = X-COMPT OF BALL SCREEN COORDS
i = 1
X > Xmin(Row, i) AND i <= 12 ?
NO
i = i+1
YES
i > 12 ?
YES
ERROR
EXIT
EYEVIEW NUMBER (EVIEW) = EVIEW_MAT(i)
EYEVIEW FRAME NUMBER = FRAME_MAT(EVIEW)
EXIT

FIG. 14

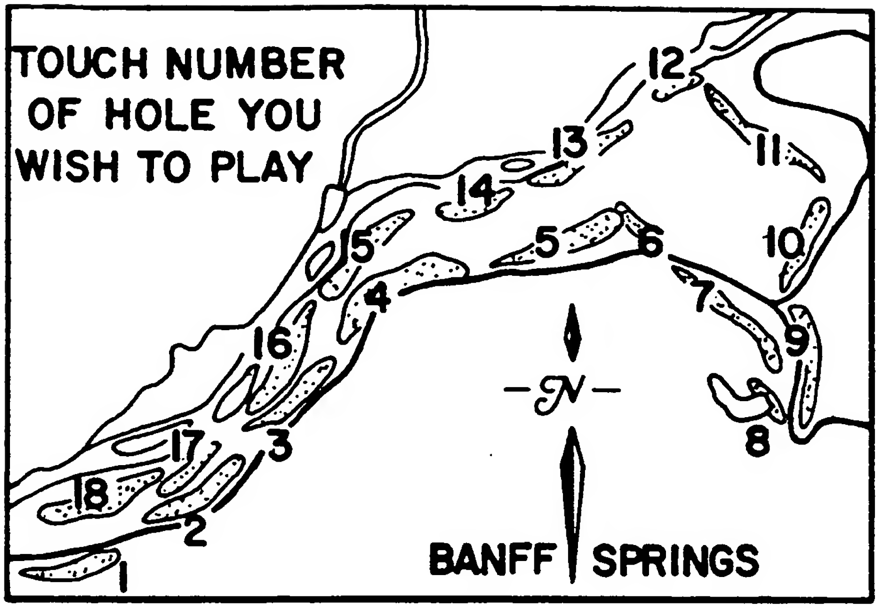
TOUCH NUMBER OF HOLE YOU WISH TO PLAY
12
13
11
14
5
6
10
15
4
7
16
9
8
17
3
18
2
1
BANFF SPRINGS

FIG. 15

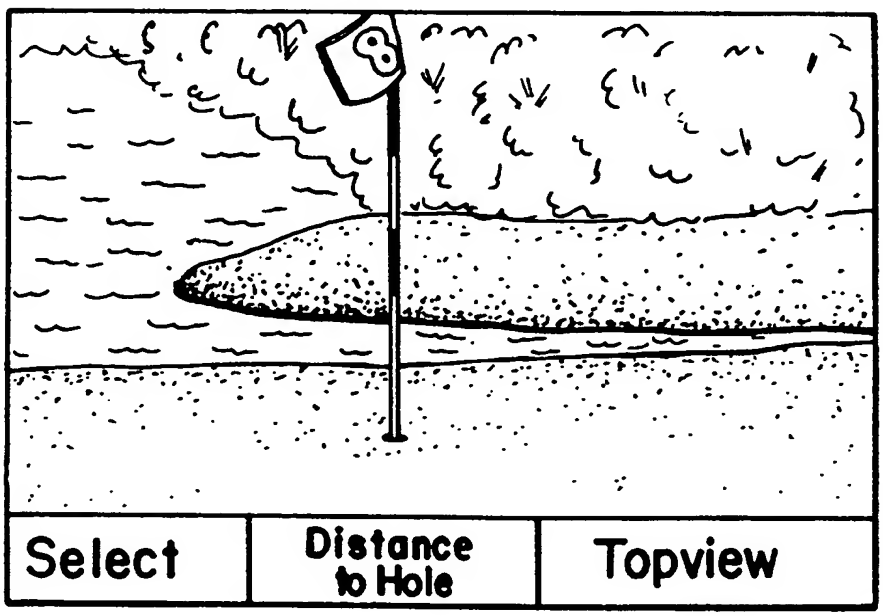
8
Select
Distance to Hole
Topview

FIG. 16